

New Hampshire Volunteer River Assessment Program 2005 Pennichuck Brook Water Quality Report



Photo: Tributary to Witches Brook (01-XWB), Amherst

Prepared by:

State of New Hampshire
Department of Environmental Services
Water Division
Watershed Management Bureau

February 2006



**New Hampshire Volunteer River Assessment Program
2005 Pennichuck Brook Water Quality Report**

State Of New Hampshire
Department of Environmental Services
P.O. Box 95
29 Hazen Drive
Concord, New Hampshire 03302-0095

Michael P. Nolin
Commissioner

Harry T. Stewart
Director
Water Division

Prepared By:
Ted Walsh
Jen Drociak
Katie Zink

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ACKNOWLEDGEMENTS

The New Hampshire Department of Environmental Services (NHDES) -Volunteer River Assessment Program (VRAP) extends sincere thanks to the volunteers of the Pennichuck Brook VRAP Group and the Nashua Regional Planning Commission for their efforts during 2005. This report was created solely from the data collected by the volunteers listed below. Their time and dedication is an expression of their genuine concern for local water resources and has significantly contributed to our knowledge of river and stream water quality in New Hampshire.

2005 Pennichuck Brook Volunteers

Allan Fuller

Jon Heiss

Paul Johnson

Anne Krantz

Jim Mulvey

Kathryn Nelson

1. INTRODUCTION

1.1. Purpose of Report

Each year the VRAP prepares and distributes a water quality report for each volunteer group that is based solely on the water quality data collected by that volunteer group during a specific year. The reports summarize and interpret the data, particularly as they relate to New Hampshire surface water quality standards, and serve as a teaching tool and guidance document for future monitoring activities by the individual volunteer groups.

1.2. Report Format

Each report includes the following:

❖ Volunteer River Assessment Program (VRAP) Overview

This section includes a discussion of the history of VRAP, the technical support, training and guidance provided by NHDES, and how data is transmitted to the volunteers and used in surface water quality assessments.

❖ Monitoring Program Description

This section provides a description of the volunteer group's monitoring program including monitoring objectives as well as a table and map showing sample station locations.

❖ Results and Discussion

Water quality data collected during the year are summarized on a parameter-by-parameter basis using (1) a summary table that includes the number of samples collected, data ranges, the number of samples meeting New Hampshire water quality standards, and the number of samples adequate for water quality assessments at each station, (2) a discussion of the data, (3) a list of applicable recommendations, and (4) a river graph showing the range of measured values at each station. Sample results reported as less than the detection limit were assumed equal to one-half the detection limit on the river graphs. This approach simplifies the understanding of the parameter of interest, and specifically helps one to visualize how the river or watershed is functioning from upstream to downstream. In addition, this format allows the reader to better understand potential pollution areas and target those areas for additional sampling or environmental enhancements. Where applicable, the river graph also shows New Hampshire surface water quality standards or levels of concern for comparison purposes.

❖ **Appendix A – Data**

This appendix includes a spreadsheet showing the data results and additional information, such data results which do not meet New Hampshire surface water quality standards, and data that is unusable for assessment purposes due to quality control requirements.

❖ **Appendix B – Interpreting VRAP Water Quality Parameters**

This appendix includes a brief description of water quality parameters typically sampled by VRAP volunteers and their importance, as well as applicable state water quality criteria or levels of concern.

❖ **Appendix C – Glossary of River Ecology Terms**

This appendix contains a list of terms commonly used when discussing river ecology and water quality.

2. PROGRAM OVERVIEW

2.1. Past, Present, and Future

In 1998, the New Hampshire Department of Environmental Services (NHDES) initiated the New Hampshire Volunteer River Assessment Program (VRAP) as a means of expanding public education of water resources in New Hampshire. VRAP promotes awareness and education of the importance of maintaining water quality in rivers and streams. VRAP was created in the wake of the success of the existing New Hampshire Volunteer Lake Assessment Program (VLAP), which provides educational and stewardship opportunities pertaining to lakes and ponds to New Hampshire's residents.

Today, VRAP continues to serve the public by providing water quality monitoring equipment, technical support, and educational programs. In 2005, VRAP supported twenty-eight volunteer groups on numerous rivers and watersheds throughout the state. These volunteer groups conduct water quality monitoring on an ongoing basis. The work of the VRAP volunteers increases the amount of river water quality information available to local, state and federal governments, which allows for effective financial resource allocation and watershed planning.

2.2. Technical Support

VRAP lends and maintains water quality monitoring kits for volunteer groups throughout the state. The kits contain electronic meters and supplies for "in-the-field" measurements of water temperature, dissolved oxygen, pH, specific conductance (conductivity), and turbidity. These are the core parameters typically measured by volunteers. However, other water quality parameters such as nutrients, metals, and *E. coli* can also be studied by volunteer groups, although VRAP does not always provide funds to cover laboratory analysis costs. Thus, VRAP encourages volunteer groups to pursue other fundraising activities such as association membership fees, special events, in-kind services (non-monetary contributions from individuals and organizations), and grant writing.

VRAP typically recommends sampling every other week during the summer, and volunteer groups are encouraged to organize a long-term sampling program in order to begin to determine trends in river conditions. Each year volunteers design and arrange a sampling schedule in cooperation with NHDES staff. Project designs are created through a review and discussion of existing water quality information, such as known and perceived problem areas or locations of exceptional water quality. The interests, priorities, and resources of the partnership determine monitoring locations, parameters, and frequency.

Water quality measurements repeated over time create a picture of the fluctuating conditions in rivers and streams and help to determine where improvements, restoration or preservation may benefit the river and the communities it supports. Water quality results are also used to determine if a

river is meeting surface water quality standards. Volunteer monitoring results, meeting DES Quality Assurance and Quality Control (QA/QC) requirements, supplement the efforts of DES to assess the condition of New Hampshire surface waters. The New Hampshire Surface Water Quality Regulations are available through the DES Public Information Center at www.des.state.nh.us/wmb/Env-Ws1700.pdf or (603) 271-1975.

2.3. Training and Guidance

Each VRAP volunteer attends an annual training session to receive a demonstration of monitoring protocols and sampling techniques. Training sessions are an opportunity for volunteers to receive an updated version of monitoring techniques. During the training, volunteers have an opportunity for hand-on use of the VRAP equipment and may also receive instruction in the collection of samples for laboratory analysis. Training is accomplished in approximately two hours, after which volunteers are certified in the care, calibration, and use of the VRAP equipment. In some cases, veteran group coordinators can attend a “train the trainer” session. In these trainings the group coordinator receives an update in sampling protocols and techniques and will then train the individual volunteers of their respective group.

VRAP groups conduct sampling according to a prearranged monitoring schedule and VRAP protocols. NHDES staff from the VRAP program aim to visit each group annually during a scheduled sampling events to verify that volunteers successfully follow the VRAP protocols. If necessary, volunteers are re-trained during the visit, and the group’s monitoring coordinator is notified of the result of the verification visit. VRAP groups forward water quality results to NHDES for incorporation into an annual report and state water quality assessment activities.

2.4. Data Usage

2.4.1. Annual Water Quality Reports

All data collected by volunteers are summarized in water quality reports that are prepared and distributed after the conclusion of the sampling period (typically fall or winter). Each volunteer group receives copies of the report. The volunteers can use the reports and data as a means of understanding the details of water quality, guiding future sampling efforts, or determining restoration activities.

2.4.2. New Hampshire Surface Water Quality Assessments

Along with data collected from other water quality programs, specifically the State Ambient River Monitoring Program, applicable volunteer data are used to support periodic DES surface water quality assessments. VRAP data are entered into NHDES’s Environmental Monitoring Database and are ultimately uploaded to the Environmental Protection Agency’s database, STORET.

Assessment results and the methodology used to assess surface waters are published by DES every two years (i.e., Section 305(b) Water Quality Reports) as required by the federal Clean Water Act. The reader is encouraged to log on to the DES web page to review the assessment methodology and list of impaired waters <http://www.des.state.nh.us/wmb/swqa/>.

2.5. Quality Assurance/Quality Control

In order for VRAP data to be used in the assessment of New Hampshire's surface waters, the data must meet quality control guidelines as outlined in the VRAP Quality Assurance Project Plan (QAPP). The VRAP QAPP was approved by NHDES and reviewed by EPA in the summer of 2003. The QAPP is reviewed annually and is officially updated and approved every five years. The VRAP Quality Assurance/Quality Control (QA/QC) measures include a six-step approach to ensuring the accuracy of the equipment and consistency in sampling efforts.

- ❖ **Calibration:** Prior to each measurement, the pH and dissolved oxygen meters are calibrated. Conductivity and turbidity meters are calibrated and/or checked against a known standard before the first measurement and after the last one.
- ❖ **Replicate Analysis:** A second measurement by each meter is taken from the original sample at one of the stations during the sampling day. The replicate analysis should not be conducted at the same station over and over again, but should be conducted at different stations throughout the monitoring season.
- ❖ **6.0 pH Standard:** A reading of the pH 6.0 buffer is recorded at one of the stations during the sampling day. If the same sampling schedule is used throughout the monitoring season, the 6.0 pH standard check should be conducted at different stations.
- ❖ **Zero Oxygen Standard:** A reading of a zero oxygen solution is recorded at one of the stations during the sampling day. If the same sampling schedule is used throughout the monitoring season, the zero oxygen standard check should be conducted at different stations.
- ❖ **DI Turbidity Blank:** A reading of the DI blank is recorded at one of the stations during the sampling day. If the same sampling schedule is used throughout the monitoring season, the blank check should be conducted at different stations.
- ❖ **Post-Calibration:** At the conclusion of each sampling day, all meters are calibrated.

2.5.1. Measurement Performance Criteria

Precision is calculated for field and laboratory measurements through measurement replicates (instrumental variability) and is calculated for each sampling day. The use of VRAP data for assessment purposes is contingent on compliance with a parameter-specific relative percent difference (RPD) as derived from equation 1, below. Any data exceeding the limits of the individual measures are disqualified from surface water quality assessments. All data that exceeds the limits defined by the VRAP QAPP are acknowledged in the data tables with an explanation of why the data was unusable. Table 1 shows typical parameters studied under VRAP and the associated quality control procedures.

(Equation 1)

$$RPD = \frac{|x_1 - x_2|}{\frac{x_1 + x_2}{2}} \times 100 \%$$

where x_1 is the original sample and x_2 is the replicate sample

Table 1. Field Analytical Quality Controls

Water Quality Parameter	QC Check	QC Acceptance Limit	Corrective Action	Person Responsible for Corrective Action	Data Quality Indicator
Temperature	Measurement replicate	± 0.2 °C	Repeat measurement	Volunteer Monitors	Precision
Dissolved Oxygen	Measurement replicate	± 2% of saturation, or ± 0.2 mg/L	Recalibrate instrument, repeat measurement	Volunteer Monitors	Precision
	Known buffer (zero O ₂ solution)	<0.5 mg/L	Recalibrate instrument, repeat measurement	Volunteer Monitors	Relative accuracy
pH	Measurement replicate	± 0.1 std units	Recalibrate instrument, repeat measurement	Volunteer Monitors	Precision
	Known buffer (pH = 6.0)	± 0.1 standard units	Recalibrate instrument repeat measurement	Volunteer Monitors	Accuracy
Specific Conductance	Measurement replicate	± 30 µS/cm	Recalibrate instrument, repeat measurement	Volunteer Monitors	Precision
	Method blank (Zero air reading)	± 5.0 µS/cm	Recalibrate instrument, repeat measurement	Volunteer Monitors	Accuracy
Turbidity	Measurement replicate	± 0.1 NTU	Recalibrate instrument, repeat measurement	Volunteer Monitors	Precision
	Method blank (DI Water)	± 0.1 NTU	Recalibrate instrument, repeat measurement	Volunteer Monitors	Accuracy

3. METHODS

During the summer of 2005, volunteers from the Pennichuck Brook VRAP Group and the Nashua Regional Planning Commission began water quality monitoring in the Pennichuck Brook watershed. The goal of this effort was to provide water quality data from the Pennichuck River relative to surface water quality standards and to allow for the assessment of the river for support of aquatic life. The Pennichuck Brook watershed is an important source of drinking water for the greater Nashua area. The establishment of a long-term monitoring program will allow for an understanding of the river's dynamics, or variations on a station-by-station and year-to-year basis. The data can also serve as a baseline from which to determine any water pollution problems in the river and/or watershed. The Volunteer River Assessment Program has provided field training, equipment, and technical assistance.

During 2005, trained volunteers from the Pennichuck Brook VRAP Group monitored water quality at eight stations in the Pennichuck Brook watershed (Figure 1, Table 2). Stations IDs are designated using a three letter code to identify the waterbody name plus a number indicating the relative position of the station. The higher the station number the more upstream the station is in the watershed.

Pennichuck Brook and all its tributaries and impoundments and all their tributaries, in the towns of Hollis, Milford, Amherst, Merrimack, and the city of Nashua, from the outlet of Pennichuck Pond to the crest of the Supply Pond dam, are considered Class A waters. All other portions of the Pennichuck Brook watershed are designated as Class B waters.

Water quality monitoring was conducted from June to September. In-situ measurements of water temperature, air temperature, dissolved oxygen, pH, and specific conductance were taken using handheld meters provided by NHDES. Samples for *E.coli*, Total Suspended Solids, Orthophosphate, and Total Kjeldahl Nitrogen were taken using sterile and/or preserved bottles supplied by the ChemServe laboratory in Milford and the Nashua Wastewater Treatment Facility. Samples were stored on ice during transport from the field to the laboratory. Table 3 summarizes the parameters measured, laboratory standard methods, and equipment used.

Table 2. Sampling Stations for the Pennichuck Brook, NHDES VRAP, 2005

Station ID	Class	Waterbody Name	Location	Town	Elevation* (Ft.)
08-WCH	A	Witches Brook	Silver Lake Road	Hollis	200
03-XWB	A	Unnamed Tributary To Witches Brook	Route 122 Bridge	Amherst	200
01-XWB	A	Unnamed Tributary To Witches Brook	End of Northern Boulevard	Amherst	200
01-WCH	A	Witches Brook	South Merrimack Road Bridge	Hollis	200
09-XPB	A	Unnamed Tributary To Pennichuck Brook	Route 101A Bridge	Hollis	200
12-PEN	B	Pennichuck Brook	Nevins Road Bridge	Hollis	200
01-MUD	B	Muddy Brook	Fraley Road Bridge	Hollis	200
10-PEN	A	Pennichuck Brook	Railroad Bridge	Hollis	200

*Elevations have been rounded off to 100-foot increments for calibration of dissolved oxygen meter

Figure 1. Pennichuck Brook Watershed and Monitoring Stations 2005

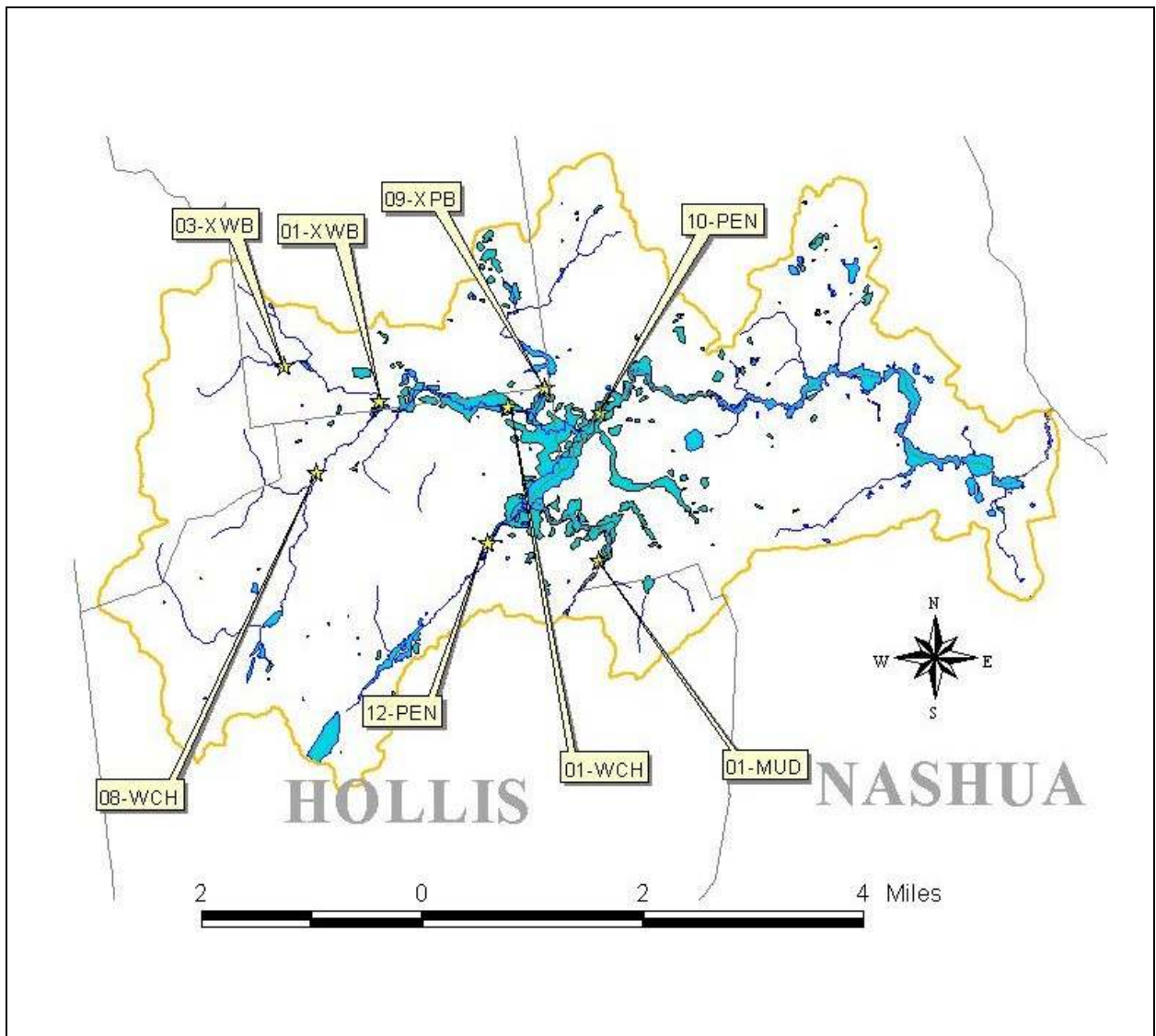


Table 3. Sampling and Analysis Methods

Parameter	Sample Type	Standard Method	Equipment Used	Laboratory
Temperature	In-Situ	SM 2550	YSI 95	-----
Dissolved Oxygen	In-Situ	SM 4500 O G	YSI 95	-----
pH	In-Situ	SM 4500 H+	Orion 210A+	-----
Specific Conductance	In-Situ	SM 2510	YSI 30	-----
E.coli	Bottle (Sterile)	EPA 1103.1	-----	Nashua WWTF
Orthophosphate	Bottle	EPA 365.2	-----	Chem Serve
Total Suspended Solids	Bottle	EPA 160.2	-----	Chem Serve
Total Kjeldahl Nitrogen	Bottle	EPA 351.3	-----	Chem Serve

4. RESULTS AND DISCUSSION

4.1. Dissolved Oxygen

Seven measurements were taken in the field for dissolved oxygen concentration at eight stations on the mainstem and tributaries of Pennichuck Brook (Table 4). Of the 56 measurements taken, all met quality assurance/quality control (QA/QC) requirements and are usable for New Hampshire's 2006 surface water quality report to the Environmental Protection Agency.

The Class A New Hampshire surface water quality standard for dissolved oxygen is a minimum concentration of 6.0 mg/L **and** a minimum daily average saturation of 75%. The Class B New Hampshire surface water quality standard for dissolved oxygen includes a minimum concentration of 5.0 mg/L **and** a minimum daily average of 75 % of saturation. In other words, there are criteria for both concentration and saturation that must be met before the river can be assessed as meeting dissolved oxygen standards. Table 4 reports only dissolved oxygen concentration as more detailed analysis is required to determine if instantaneous dissolved oxygen saturation measurements are above or below water quality standards.

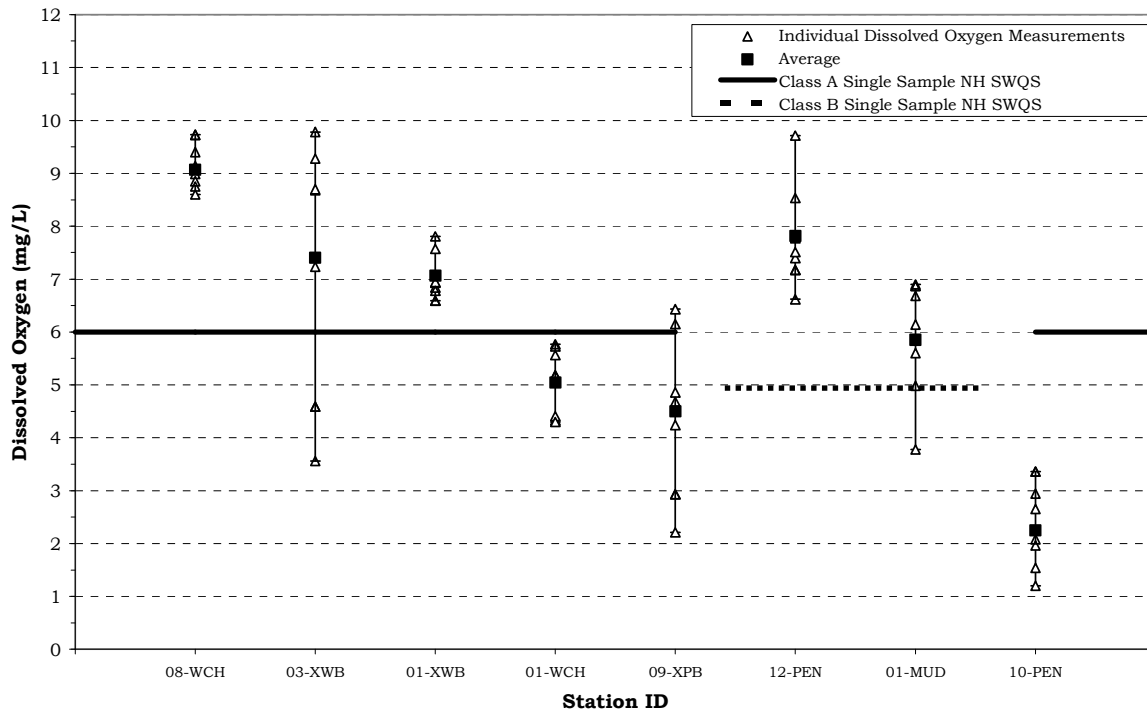
Table 4. Dissolved Oxygen Concentration Data Summary – Pennichuck Brook, 2005

Station ID	Class	Samples Collected	Data Range (mg/l)	Acceptable Samples Not Meeting NH Class A/B Standards	Number of Usable Samples for 2006 NH Surface Water Quality Assessment
08-WCH	A	7	8.60 - 9.73	0	7
03-XWB	A	7	3.56 - 9.78	2	7
01-XWB	A	7	6.59 - 7.81	0	7
01-WCH	A	7	4.30 - 5.77	7	7
09-XPB	A	7	2.21 - 6.43	5	7
12-PEN	B	7	6.62 - 9.71	0	7
01-MUD	B	7	3.78 - 6.90	2	7
10-PEN	A	7	1.20 - 3.36	7	7
Total Number of Useable Samples for 2006 NH Surface Water Quality Assessment					56

Dissolved oxygen concentration levels were variable with the average ranging from 2.3 mg/L to 9.1 mg/L (Figure 2). Stations 01-WCH and 10 PEN had dissolved oxygen readings below the New Hampshire surface water quality standard on all occasions. Station 09-XPB had dissolved oxygen readings below the standard on all but two occasions. Levels of dissolved oxygen sustained above the standards are considered adequate for the support of aquatic life and

other desirable water quality conditions. Stations where the instantaneous dissolved oxygen standard was not met could potentially have a dissolved oxygen problem and further investigation is warranted. Low dissolved oxygen levels can be the result of natural conditions (e.g., the presence of wetlands or stagnant water caused by a beaver dam).

**Figure 2. Dissolved Oxygen Statistics for the Pennichuck Brook Watershed
June 21 - September 26, 2005 NHDES VRAP**



Recommendations

- ❖ Continue sampling at all stations in order to develop a long-term data set to better understand trends as time goes on.
- ❖ If possible, take measurements between 5:00 a.m. and 10:00 a.m., which is when dissolved oxygen is usually the lowest, and between 2:00 p.m. and 7:00 p.m. when dissolved oxygen is usually the highest. In general, dissolved oxygen levels are lowest in the early morning when there is low photosynthetic activity and a peak in respiration from organisms throughout the water column. This is the time of least oxygen production and greatest carbon dioxide emission. Peak dissolved oxygen levels occur when photosynthetic activity is at its peak. The greater the amount of photosynthetic activity the greater the production of oxygen as a byproduct of photosynthesis.
- ❖ Next year incorporate the use of in-situ dataloggers to automatically record dissolved oxygen saturation levels during a period of several days. This will allow for the calculation of the daily average for dissolved oxygen per cent saturation. Dataloggers can be put in the water for a period of several days and collect data at specific time intervals (e.g. every 15 minutes). The use of these instruments is dependent upon availability, and requires coordination with NHDES.

4.2. pH

Eight measurements were taken in the field for pH at eight stations on the mainstem and tributaries of Pennichuck (Table 5). Of the 64 measurements taken, all met quality assurance/quality control (QA/QC) requirements and are usable for New Hampshire's 2006 surface water quality report to the Environmental Protection Agency.

The Class A and B New Hampshire surface water quality standard is 6.5 - 8.0, unless naturally occurring.

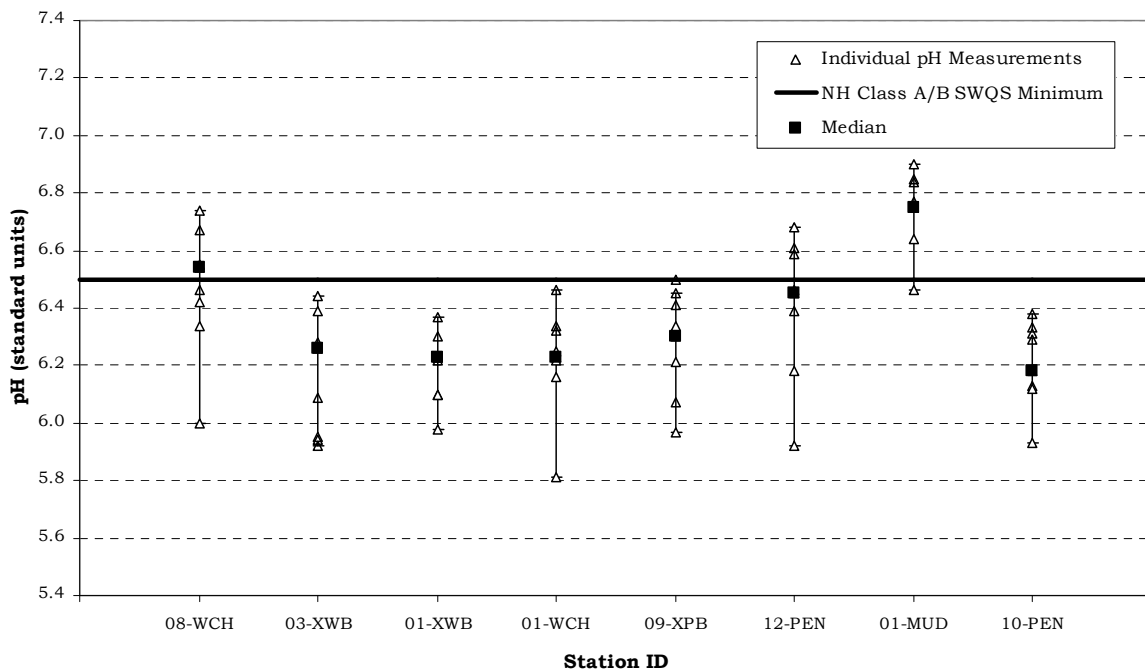
Table 5. pH Data Summary – Pennichuck Brook, 2005

Station ID	Class	Samples Collected	Data Range (standard units)	Acceptable Samples Not Meeting NH Class A/B Standards	Number of Usable Samples for 2006 NH Surface Water Quality Assessment
08-WCH	A	8	6.00 - 6.74	4	8
03-XWB	A	8	5.92 - 6.44	8	8
01-XWB	A	8	5.98 - 6.37	8	8
01-WCH	A	8	5.81 - 6.46	8	8
09-XPB	A	8	5.97 - 6.45	7	8
12-PEN	B	8	5.92 - 6.68	5	8
01-MUD	B	8	6.46 - 6.90	1	8
10-PEN	A	8	5.93 - 6.38	8	8
Total Number of Useable Samples for 2006 NH Surface Water Quality Assessment					64

A majority of the pH measurements were below the New Hampshire surface water quality standard (Figure 3). Four of the stations (03-XWB, 01-XWB, 01-WCH, 10-PEN) had pH measurements below the New Hampshire surface water quality standard on all occasions.

Lower pH measurements are likely the result of natural conditions such as the soils, geology, or the presence of wetlands in the area. Rain and snow falling in New Hampshire is relatively acidic, which can also affect pH levels; after the spring melt or significant rain events, surface waters will generally have a lower pH.

**Figure 3. pH Statistics for the Pennichuck Brook Watershed
June 21 - September 26, 2005 NHDES VRAP**



Recommendations

- ❖ Continue sampling at all stations in order to develop a long-term data set to better understand trends as time goes on.
- ❖ Consider sampling for pH in some of the tributaries and wetland areas that are influencing the pH of stations with measurements below state standards. Site conditions are considered along with pH measurements because of the narrative portion of the pH standard. RSA 485-A:8 states that pH of Class B waters *shall be between 6.5 and 8.0, except when due to natural causes*. Wetlands can lower the pH of a river naturally by releasing tannic and humic acids from decaying plant material. If the sampling location is influenced by wetlands or other natural conditions, then the low pH measurements are not considered a violation of water quality standards. It is important to note that the New Hampshire water quality standard for pH is fairly conservative, thus pH levels slightly below the standard are not necessarily harmful to aquatic life. In this case, additional information about factors influencing pH levels is needed.

4.3. Specific Conductance

Eight measurements were taken in the field for specific conductance at eight stations on the mainstem and tributaries of Pennichuck Brook [Table 6). Of the 64 measurements taken, all met quality assurance/quality control (QA/QC) requirements and are usable for New Hampshire's 2006 surface water quality report to the Environmental Protection Agency.

New Hampshire surface water quality standards do not contain numeric limits for specific conductance.

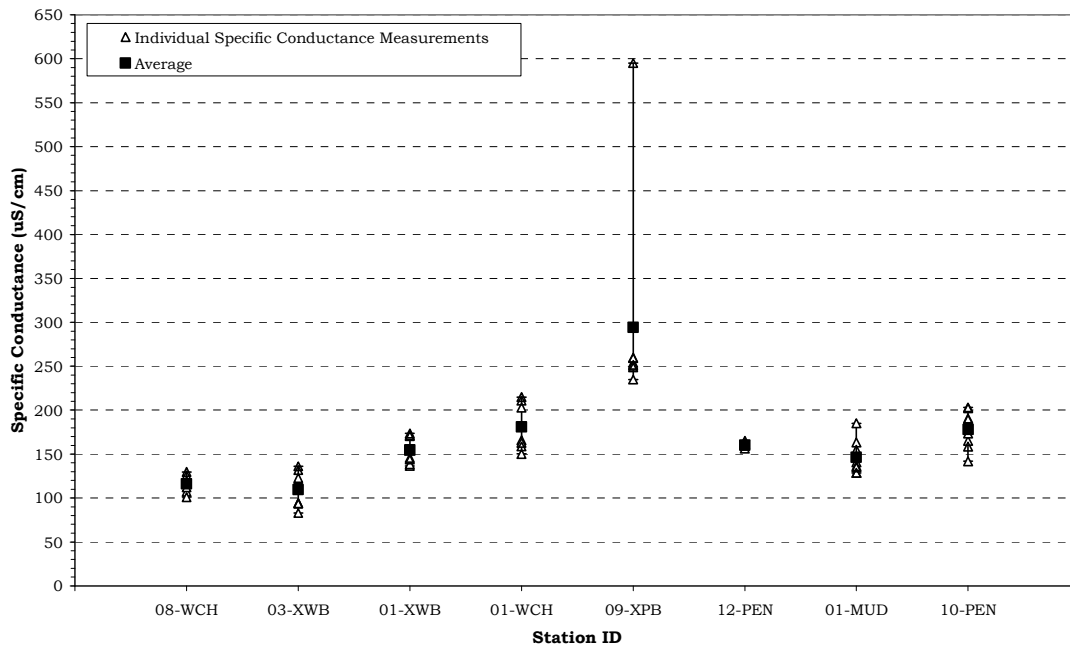
Table 6. Specific Conductance Data Summary – Pennichuck Brook, 2005

Station ID	Class	Samples Collected	Data Range ($\mu\text{S}/\text{cm}$)	Acceptable Samples Not Meeting NH Class B Standards	Number of Usable Samples for 2006 NH Surface Water Quality Assessment
08-WCH	A	8	101.0 - 129.7	Not Applicable	8
03-XWB	A	8	83.0 - 136.1	N/A	8
01-XWB	A	8	136.5 - 173.5	N/A	8
01-WCH	A	8	150.3 - 214.8	N/A	8
09-XPB	A	8	234.8 - 595.0	N/A	8
12-PEN	B	8	156.4 - 165.3	N/A	8
01-MUD	B	8	128.5 - 185.1	N/A	8
10-PEN	A	8	141.9 - 203.1	N/A	8
Total Number of Useable Samples for 2006 NH Surface Water Quality Assessment					64

Specific conductance levels were variable with the average ranging from 110 $\mu\text{S}/\text{cm}$ to 294 $\mu\text{S}/\text{cm}$ (Figure 4). Higher specific conductance levels can be indicative of pollution from sources such as urban/agricultural runoff, road salt, failed septic systems, or groundwater pollution. Anions (negatively charged elements such as chloride) and cations (positively charged elements such as calcium) are typically found in rivers flowing through more developed areas.

The variable specific conductance levels in the Pennichuck Brook watershed indicate low pollutant levels at some stations and potentially higher levels at others.

**Figure 4. Specific Conductance Statistics for the Pennichuck Brook Watershed
June 21 - September 26, 2005 NHDES VRAP**



Recommendations

- ❖ Continue sampling at all stations in order to develop a long-term data set to better understand trends as time goes on.
- ❖ Consider collecting chloride samples at the same time specific conductance is measured. During the late winter/early spring snowmelt, higher conductivity levels are often seen due to elevated concentrations of chloride in the runoff. Conductivity levels are very closely correlated to chloride levels. Simultaneously measuring chloride and conductivity will allow for a better understanding of their relationship.

4.4. *Escherichia coli*/Bacteria

Either six or seven samples were collected for *Escherichia coli* (*E. coli*) at eight stations on the mainstem and tributaries of Pennichuck Brook (Table 7). Of the 55 measurements taken, 47 met quality assurance/quality control (QA/QC) requirements and are usable for New Hampshire's 2006 surface water quality report to the Environmental Protection Agency.

Class A NH surface water quality standards for *E.coli* are as follows:

- <153 cts/100 ml, based on any single sample, or
- <47 cts/100 ml, based on a geometric mean calculated from three samples collected within a 60-day period.

Class B NH surface water quality standards for *E.coli* are as follows:

- <406 cts/100 ml, based on any single sample, or
- <126 cts/100 ml, based on a geometric mean calculated from three samples collected within a 60-day period.

Table 7. *E.coli* Data Summary – Pennichuck Brook Watershed, 2005

Station ID	Class	Samples Collected	Data Range (cts/100ml)	Acceptable Samples Not Meeting NH Class A/B Standards	Number of Usable Samples for 2006 NH Surface Water Quality Assessment
08-WCH	A	7	4 - 84	0	6 ^a
03-XWB	A	7	4 - 740	4	6 ^a
01-XWB	A	7	40 - 470	4	6 ^a
01-WCH	A	7	8 - 1140	4	6 ^a
09-XPB	A	6	102 - 280	4	5 ^a
12-PEN	B	7	8 - 60	0	6 ^a
01-MUD	B	7	4 - 300	0	6 ^a
10-PEN	A	7	4 - 256	1	6 ^a
Total Number of Useable Samples for 2006 NH Surface Water Quality Assessment					47

^a 8/16/05 Relative % Difference of Replicate Exceeded VRAP QAPP Requirements

Four stations (03 XWB, 01-XWB, 01-WCH, 09-XPB) on four occasions had a single sample level of *E.coli* which exceeded the New Hampshire surface water quality standard (Figure 5). Station 10-PEN exceeded the single sample standard once. Stations 08-WCH, 12-PEN, and 01-MUD had no samples that exceeded the single sample standard.

In order to fully determine whether a waterbody is meeting surface water standards for *E. coli* a geometric mean must be calculated. A geometric mean is calculated using three samples collected within a 60-day period. Stations 08-WCH, 12-PEN, and 01-MUD were above the geometric mean standard on all occasions. All other stations had multiple violations of the geometric mean standard.

Several factors can contribute to elevated *E. coli* levels, including, but not limited to rain storms, low river flows, the presence of wildlife (e.g., birds), and the presence of septic systems along the river.

**Figure 5. Escherichia coli Statistics for the Pennichuck Brook Watershed
June 21 - September 26, 2005 NHDES VRAP**

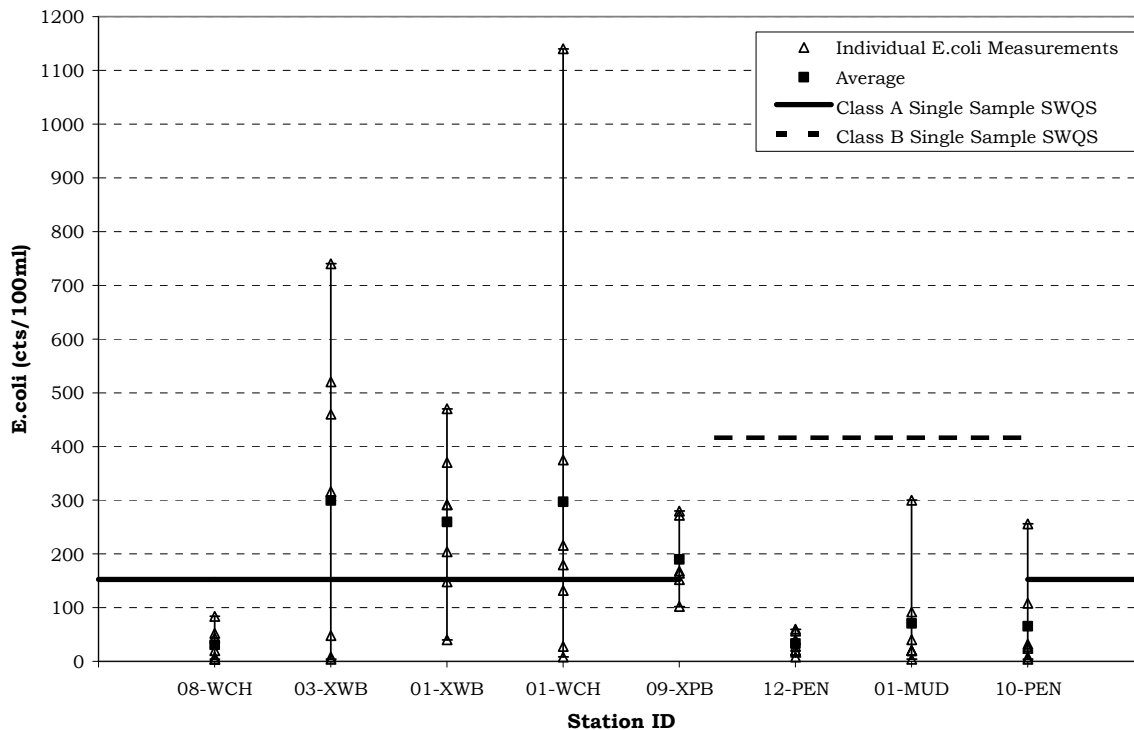


Table 8. *E. coli* Geometric Mean Data Summary – Pennichuck Brook, 2005

Station ID	Class	Geometric Means Calculated	Geometric Means Not Meeting NH Class A/B Standards	Number of Usable Geometric Means for 2006 NH Surface Water Quality Assessment
08-WCH	A	4	0	4
03-XWB	A	4	3	4
01-XWB	A	2	2	2
01-WCH	A	4	4	4
09-XPB	A	3	3	3
12-PEN	B	4	0	4
01-MUD	B	4	0	4
10-PEN	A	4	2	4
Total Number of Useable Geometric Means for 2006 NH Surface Water Quality Assessment				29

Recommendations

- ❖ Continue collecting three samples within any 60-day period during the summer to allow for determination of geometric means.
- ❖ Continue to document river conditions and station characteristics (including the presence of wildlife in the area during sampling).
- ❖ At stations with particularly high bacteria levels volunteers can investigate further by moving upstream and taking additional measurements. This will facilitate isolating the location of the cause of the elevated bacteria levels. Those sampling should also look for any potential sources of bacteria such as emission pipes and failed septic systems.

4.5. Total Suspended Solids (TSS)

Eight samples were collected for total suspended solids at eight stations on the mainstem and tributaries of Pennichuck Brook (Table 9). Of the 64 measurements taken, 56 met quality assurance/quality control (QA/QC) requirements and are usable for New Hampshire's 2006 surface water quality report to the Environmental Protection Agency.

New Hampshire surface water quality standards do not contain numeric limits for total suspended solids.

Table 9. Total Suspended Solids Data Summary – Pennichuck Brook, 2005

Station ID	Class	Samples Collected	Data Range (mg/l)	Acceptable Samples Not Meeting NH Class A/B Standards	Number of Usable Samples for 2006 NH Surface Water Quality Assessment
08-WCH	A	8	2 - 2	Not Applicable	7 ^a
03-XWB	A	8	2 - 5	N/A	7 ^a
01-XWB	A	8	2 - 34	N/A	7 ^a
01-WCH	A	8	2 - 2	N/A	7 ^a
09-XPB	A	8	2 - 51	N/A	7 ^a
12-PEN	B	8	2 - 4	N/A	7 ^a
01-MUD	B	8	2 - 2	N/A	7 ^a
10-PEN	A	8	2 - 27	N/A	7 ^a
Total Number of Useable Samples for 2006 NH Surface Water Quality Assessment					56

^a 8/16/05 Relative % Difference of Replicate Exceeded VRAP QAPP Requirements

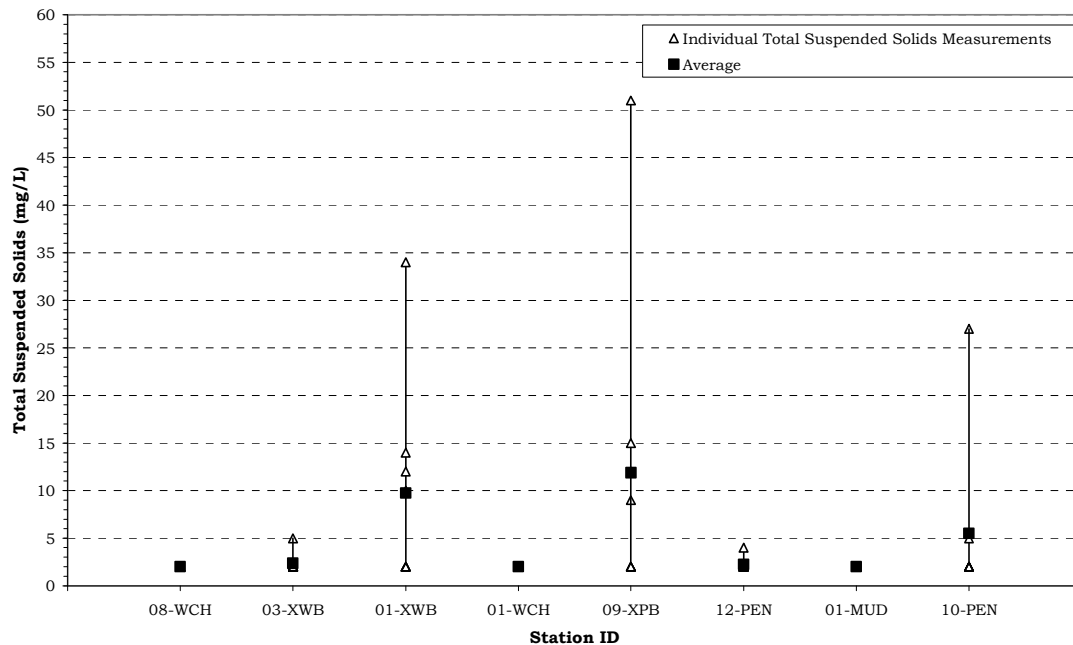
52 of the 64 total suspended solid samples collected were below the detection limit of 4 mg/L. Stations 01-XWB, 09-XPB, and 10-PEN had total suspended solid measurements that were significantly higher than other samples measured at those stations during the season.

Total suspended solids is the portion of matter suspended in a water column that can be retained through a filter during the processing of the sample. Total suspended solids can include materials such as sediment, silt, decaying organic matter, industrial pollutants and wastewater effluent. High concentrations of total suspended solids have a negative impact on the palatability of drinking water and the health of aquatic life.

Although clean waters are associated with low total suspended solids there is a high degree of natural variability involved. Precipitation often contributes to

increased solids by flushing sediment, organic matter and other materials from the surrounding landscape into surface waters. However, human activities such as removal of vegetation near surface waters and disruption of nearby soils can lead to dramatic increases in total suspended solid levels. In general it is typical to see a rise in total suspended solid levels in more developed areas due to increased runoff.

**Figure 6. Total Suspended Solids Statistics for the Pennichuck Brook Watershed
June 21 - September 26, 2005 NHDES VRAP**



Recommendations

- ❖ Continue sampling at all stations in order to develop a long-term data set to better understand trends as time goes on.
- ❖ Collect samples during wet weather. This will help us to understand how the river responds to runoff and sedimentation.
- ❖ If a higher than normal measurements chronically occur, volunteers can investigate further by moving upstream and taking additional measurements. This will facilitate isolating the location of the cause of the elevated total suspended solid levels. In addition, take good field notes and photographs. If human activity is suspected or verified as the source of elevated total suspended solid levels volunteers should contact NHDES.

4.6. Total Kjeldahl Nitrogen (TKN)

Seven samples were collected for total kjeldahl nitrogen at eight stations on the mainstem and tributaries of Pennichuck Brook in Amherst and Nashua (Table 10). Of the 56 measurements taken, 40 met quality assurance/quality control (QA/QC) requirements and are usable for New Hampshire's 2006 surface water quality report to the Environmental Protection Agency.

There is no numeric standard for TKN for Class A or B waters. The narrative standard states that "unless naturally occurring, shall contain no nitrogen in such concentrations that would impair any existing or designated uses."

Table 10. Total Kjeldahl Nitrogen Data Summary – Pennichuck Brook, 2005

Station ID	Class	Samples Collected	Data Range (mg/l)	Acceptable Samples Not Meeting NH Class A/B Standards	Number of Usable Samples for 2006 NH Surface Water Quality Assessment
08-WCH	A	7	0.64 - 3.03	Not Applicable	5 ^{a,b}
03-XWB	A	7	0.70 - 2.27	N/A	5 ^{a,b}
01-XWB	A	7	0.75 - 2.36	N/A	5 ^{a,b}
01-WCH	A	7	0.68 - 1.69	N/A	5 ^{a,b}
09-XPB	A	7	0.994 - 3.09	N/A	5 ^{a,b}
12-PEN	B	7	0.66 - 1.41	N/A	5 ^{a,b}
01-MUD	B	7	0.85 - 1.55	N/A	5 ^{a,b}
10-PEN	A	7	1.11 - 2.34	N/A	5 ^{a,b}
Total Number of Useable Samples for 2006 NH Surface Water Quality Assessment					40

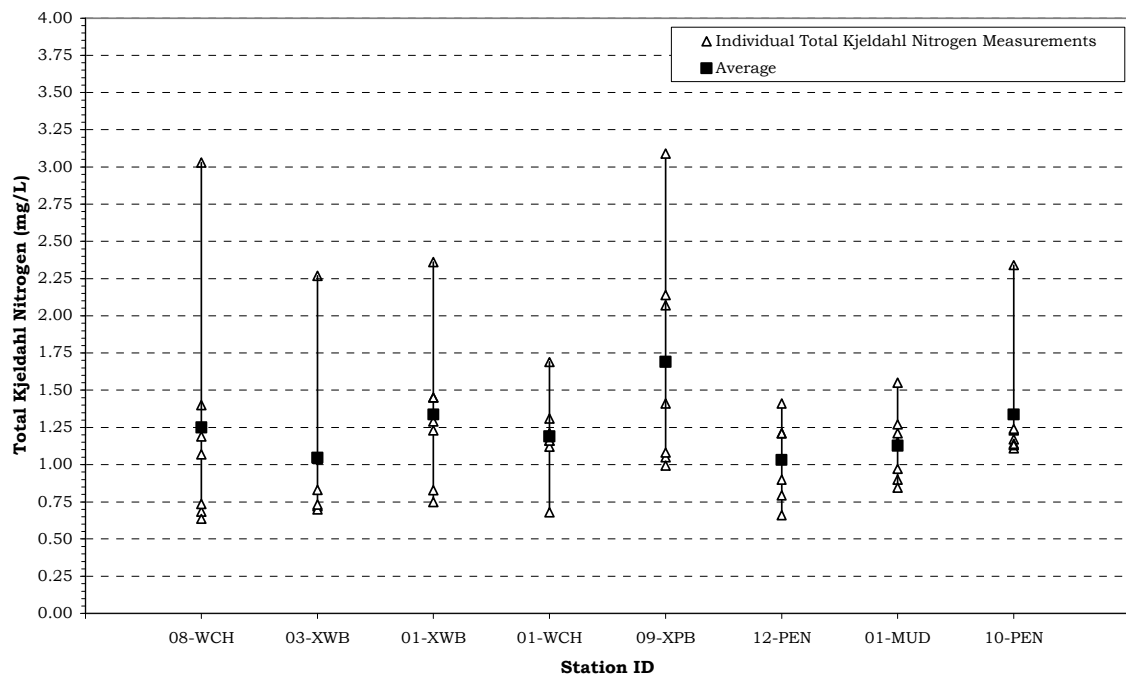
^a 6/21/05 Relative % Difference of Replicate Exceeded VRAP QAPP Requirements

^b 9/13/05 Relative % Difference of Replicate Exceeded VRAP QAPP Requirements

TKN concentrations were consistent and relatively high at all stations with the average ranging from 1.0 mg/L to 1.7 mg/L.

TKN is unoxidized nitrogen and a measurement of the combined concentration of organic nitrogen and ammonia. Nitrogen is naturally occurring in soil in organic forms from decomposing plant and animal matter. Bacteria in the soil then convert nitrogen to nitrate, a nitrogen-oxygen chemical unit. Primary sources which can cause increased nitrate levels are human sewage, livestock manure, and agricultural fertilizers. Higher TKN values may also be indicative of high production rates, algal growth and decomposing organics.

**Figure 7. Total Kjeldahl Nitrogen Statistics for the Pennichuck Brook Watershed
June 21 - September 26, 2005 NHDES VRAP**



Recommendations

- ❖ Continue sampling at all stations in order to develop a long-term data set to better understand trends as time goes on.
- ❖ Consider monitoring for additional nitrogen based parameters such as ammonia and nitrate to better determine the source of the high TKN values.
- ❖ Consider monitoring for chlorophyll-a. High concentrations of nutrients will lead to an increase in algal growth. Because algae is a plant and contains chlorophyll-a, the concentration of chlorophyll-a found in the water will give an estimation of the concentration of algae. NHDES uses chlorophyll-a as an indicator in the assessment of surface water for primary contact recreation.
- ❖ Shoreline investigations should be conducted to look for potential sources of high nitrogen levels. Land use practices that would incorporate the use of fertilizers should be documented.

4.7. Orthophosphate, Phosphorous

Eight samples were collected for orthophosphate at eight stations on the mainstem and tributaries of Pennichuck. (Table 10) Of the 64 measurements taken, all met quality assurance/quality control (QA/QC) requirements and are usable for New Hampshire's 2006 surface water quality report to the Environmental Protection Agency.

There is no numeric standard for phosphorus for Class A or B waters. The narrative standard states that "unless naturally occurring, shall contain no phosphorus in such concentrations that would impair any existing or designated uses."

Table 11. Orthophosphate Data Summary – Pennichuck Brook, 2005

Station ID	Class	Samples Collected	Data Range (mg/l)	Acceptable Samples Not Meeting NH Class A/B Standards	Number of Usable Samples for 2006 NH Surface Water Quality Assessment
08-WCH	A	8	<0.005 - <0.01	Not Applicable	8
03-XWB	A	8	<0.005 - <0.01	N/A	8
01-XWB	A	8	<0.005 - <0.01	N/A	8
01-WCH	A	8	<0.005 - 0.02	N/A	8
09-XPB	A	8	<0.005 - <0.05	N/A	8
12-PEN	B	8	<0.005 - <0.01	N/A	8
01-MUD	B	8	<0.005 - <0.03	N/A	8
10-PEN	A	8	<0.005 - 0.03	N/A	8
Total Number of Useable Samples for 2006 NH Surface Water Quality Assessment					64

Orthophosphate concentrations were below the laboratory detection limits on most occasions at all stations. On 9/26/05 stations 01-WCH (0.02 mg/L) and 10-PEN (0.03 mg/L) each had one sample that was slightly elevated.

Under undisturbed natural conditions phosphorous is at very low levels in aquatic ecosystems. Of the three nutrients critical for aquatic plant growth; potassium, nitrogen, and phosphorous, it is usually phosphorous that is the limiting factor to plant growth. When the supply of phosphorous is increased due to human activity, algae respond with significant growth. Orthophosphate is the most stable kind of phosphate, and is the form of phosphorous used by plants.

A major source of excessive phosphorous concentrations in aquatic ecosystems can be wastewater treatment facilities, as sewage typically contains relatively high levels of phosphorus detergents. However, fertilizers used on lawns, sources of manure, and agricultural areas can also contribute significant amounts of phosphorus.

Recommendations

- ❖ Continue sampling orthophosphate at all stations in order to develop a long-term data set to better understand trends as time goes on.
- ❖ Consider sampling for total phosphorous to provide a more detailed understanding of the levels of phosphorous at each station.

APPENDIX A

2005 Pennichuck Brook Watershed Water Quality Data

APPENDIX B

Interpreting VRAP Water Quality Parameters

APPENDIX C

Glossary of River Ecology Terms